

REVISED ERADICATION PLAN FOR *CAULERPA TAXIFOLIA* IN CALIFORNIA: SURVEILLANCE, ERADICATION, AND CURRENT STATUS.

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BACKGROUND

The highly invasive Mediterranean strain of the tropical alga, *Caulerpa taxifolia*, has become established in Agua Hedionda Lagoon, Carlsbad, California, where it was first discovered in June 2000 (Figure 1). This site represents the first known occurrence of this invasive strain within the Western Hemisphere and is considered to pose a major threat to coastal ecosystems, as well as to recreational and commercial uses of resources. While the species has now been confirmed at a second site in Huntington Harbour, Huntington Beach, California, Agua Hedionda reflects the larger of the known infestations (Figure 2). It is not known whether other infestations also exist and the continued wide availability of this species in the commercial aquarium trade is of high concern.

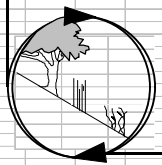
The invasive strain of this species was banned from international import or interstate commerce since 1999 through the Federal Noxious Weed Act, and legislation was recently passed 2001 in the State of California banning the possession and sale of several species of potentially invasive *Caulerpa*, including *taxifolia*. Since the Carlsbad discovery in June 2000, eradication, surveillance, and public outreach efforts, as well as eradication research and legislative efforts have been initiated and are on-going. The primary, but not the sole, focus of a Southern California *Caulerpa* Action Team (SCCAT) has been on eradication of the known infestations.

This document describes the current surveillance and eradication protocols for Agua Hedionda Lagoon, Huntington Harbour, and the surveillance effort being undertaken in and around other sites of likely introduction in southern California. The primary impetus for this document was the realization that there have been some deviations in methodologies anticipated by the document, Rapid Response and Eradication Program for the Invasive Green Alga, *Caulerpa taxifolia* at Agua Hedionda Lagoon, Carlsbad California. This document was prepared before eradication began at Agua Hedionda and before the second infestation at Huntington Harbour was discovered. Hence, it is reasonable to anticipate that the predicted methodologies would vary from the realized methodologies. Moreover, the demands of the eradication program have left little time for reporting the progress of the eradication effort. After discussing the protocols used to survey for and eradicate *Caulerpa* in southern California, this document will briefly describe the current status of the eradication effort. Finally, a protocol for future reporting will be considered.



Agua Hedionda
June 2000
Carlsbad, CA

Figure
1



Map of Known *Caulerpa taxifolia* Infestation in Huntington Harbour
October 26, 2000
Huntington Beach, CA

Figure
2

SURVEILLANCE

INSIDE LAGOON SURVEY EFFORTS (AGUA HEDIONDA AND HUNTINGTON HARBOUR)

The eradication program presently underway includes two levels of survey. The first is a high-intensity surveillance that is being used in regions of Agua Hedionda Lagoon where *Caulerpa* has not previously been identified. The second is an even higher intensity eradication-area survey used in infested areas (defined as all areas where *Caulerpa* has ever been detected plus a 162-ft [50m] buffer) or where visibility is limited.

High Intensity Surveillance

This survey method employs the use of divers being towed at 1 to 1.5 knots along transects by a small boat using survey-grade differential GPS. Early in the eradication efforts, this surveillance was initiated using a 5-meter separation between transects with the expectation that the clustered distribution of *Caulerpa* would allow areas of infestation to be identified by such methods. As eradication efforts have moved forward and a greater understanding of *Caulerpa* distribution patterns has been developed, this surveillance technique has been intensified from 5-meter, to 3-meter, and ultimately to a 1-meter spacing that is used currently to ensure complete coverage.

High intensity surveillance level surveys were employed in summer 2001 in order to comprehensively survey the entire lagoon to detect any further infestations outside of Snug Harbor. This technique is primarily intended to identify established patches that have escaped earlier detection and to survey areas with suitable water clarity.

Eradication Area Surveys

As with the high intensity surveillance discussed above, eradication area surveys are also conducted by divers. However, instead of being towed by a vessel at a slow speed, divers move at an appropriate rate along deployed transect lines, thus allowing for a more comprehensive search of areas where visibility may be reduced by poor water quality or dense eelgrass. As with the high-intensity surveillance approach, divers conducting eradication area surveys are spaced between 1 and 1.5 meters apart. Using this method it is possible to conduct intensive surveys that can locate very small fronds of *Caulerpa*, even within dense eelgrass beds.

Eradication area surveys are used in Agua Hedionda Lagoon to effectively cover areas of known infestations and in areas where visibility prevents use of towed-diver, high intensity surveys. Eradication area surveys are the sole means of surveillance in Huntington Harbour because the infestation is largely restricted to small saltwater ponds with low visibility. Moreover, the restricted nature of the ponds makes the towed diver approach impractical.

Snug Harbor Grid

Due to frequent references made to it in other documents regarding *Caulerpa* in Agua Hedionda, the “grid” in Snug Harbor should be briefly explained. Shortly after the discovery of *Caulerpa* growing in the most northern portion of the east basin of Agua Hedionda, known as Snug Harbor, a survey grid of line was immediately deployed over what was believed to be the extent of the infestation. This grid has numbered and lettered axes that allow for

systematic, repeatable surveys and facilitate mapping and recovery of discovered *Caulerpa* for treatment. This grid remains in place and is surveyed as part of regular quarterly surveys. The results of grid surveys are often reported separately from lagoon-wide surveys because they allow for simple tracking of temporal and spatial changes in *Caulerpa* distribution. Survey area, methodology, and intensity in the grid have changed very little since June 2000, whereas methodology in lagoon-wide surveys has evolved throughout the first year of the eradication, making temporal comparisons more difficult.

OUTSIDE LAGOON SURVEY EFFORTS

Agua Hedionda

Surveys have been conducted outside of the lagoon mouth with the assumption that any *Caulerpa* that had been freed in the lagoon could be transmitted out of the lagoon either by tidal action, or through the power plant cooling system. The power plant cooling water system has a mechanical traveling screen that captures and rejects most drift debris prior to it being passed through the plant to the ocean discharge. Any rejected material is disposed of in an upland landfill.

Outside of Agua Hedionda Lagoon, surveys are conducted with a combination of video, side-scan sonar, and diver surveys. Where no vegetation is present, side-scan sonar allows large areas to be effectively surveyed. Any suspect features returned by the side-scan sonar are then spot surveyed by divers or video to determine the nature of the material. Reefs offshore of Agua Hedionda are considered to be the most likely place that drift *Caulerpa* leaving the lagoon would be trapped and are therefore targeted by the diver surveys.

Huntington Harbour

The infestation at Huntington Harbour occurs in two ponds and in a small portion of the harbor itself. The infestation is in the furthest point from the mouth of the harbor. In order to ensure that *Caulerpa* did not occur elsewhere in the harbor, the entire harbor was surveyed to the mouth by divers in May 2001.

Regional Surveillance Efforts

Regionally, surveys are being conducted along the southern California coastline. Table 1 lists the surveillance sites and the search types performed. Generally, side-scan sonar has been used to thoroughly search the target water body. Any vegetation or suspicious returns from the sonar are then spot checked by divers. Additionally, divers swim along beaches, walls, rip-rap, piers, bridges, discharge points, and any other potential entry points for *Caulerpa*.

In addition to the specific survey efforts of the SCCAT, the SCCAT has prepared information advisories for public dissemination through outlets such as dive shops, dive clubs, boat ramps and clubs, internet web sites, bait and tackle shops, newspapers, and focused journals. Many local dive clubs have been briefed on *Caulerpa* and are watching for it during their recreational dives.

Table 1. Surveillance effort for southern California regional surveys (as of December 2001).

Site	Survey Days	Diver Days	Sonar
Alamitos Bay	4	9	Yes
Oceanside Harbor	2	4	Yes
Anaheim Bay	2	4	Yes
Mission Bay	11	6	Yes
Carlsbad Offshore	4	6	Yes
Marina Del Rey	3	7	Yes
Ballona 'Del Rey' Lagoon	1 (boat visual)	0	No
Newport Bay	3	0 (Volunteer)	Yes
Dana Point Marina	2	3	Yes
San Luis Rey River	1 (boat visual)	0	No
San Diego River	1 (boat visual)	0	No
Channel Islands Harbor	4	8	Yes
Ventura Harbor	2	4	Yes
Santa Barbara Harbor	2	2	Yes
King Harbor	1	0	Yes

ERADICATION IMPLEMENTATION

CONTAINMENT

When *Caulerpa* was discovered in Agua Hedionda in June 2000, the infestation was initially believed to occur in only a small portion of the lagoon (Snug Harbor). In order to prevent further spread by boating activity and to allow the eradication crew to safely conduct their work, a boom was deployed around the infestation that excluded all boat traffic. Currently it is known that the infestation areas are much larger and widespread throughout the east basin of the lagoon. Further restriction of boating activity in this basin is currently being considered by the SCCAT and City of Carlsbad. At the current time, the lagoon is open to boat use with the exception of the area originally boomed-off in Snug Harbor.

In Huntington Harbour, homeowners living on the two infested ponds were asked by their homeowners association to not enter the water until the initial treatment was completed. The shallow ponds are closed to harbor traffic and are used only by a few paddle boats and swimmers. The infestation in the adjacent portion of the harbor that is accessible by boats occurred in much deeper water (about -10 to -15 ft MLLW) where boats leave their slips rarely and were considered less likely to spread *Caulerpa* with their propeller wash due to the depth. The treatment was conducted very quickly during the winter and no harbor closures were necessary.

As part of the eradication, all identified *Caulerpa* is currently contained by covering the patches with impermeable black PVC tarps. The tarps are then sealed to the seafloor by placing sandbags on the margins of the tarps. Following chemical treatment (see below), the tarps are left in place to discourage regrowth of any viable material that may remain in the sediment.

CHEMICAL TREATMENT

Caulerpa contained under the PVC tarps is further treated with the addition of chlorine. Chlorine is currently identified as the agent with the greatest potential to quickly kill *Caulerpa* (see document entitled Investigations of herbicides for treatment of *Caulerpa taxifolia*, Merkel & Associates, 2001). Two methods have been utilized to administer chlorine to tarped patches. During the summer of 2000 at Agua Hedionda, liquid chlorine (12.5 % Sodium Hypochlorite) was pumped under the PVC tarps from a container on shore. Following the initial eradication effort and discovery of additional patches further from the containment boom, solid chlorine (Trichloroisocyanuric acid) has since been used. Pucks of solid chlorine are placed by divers prior to covering a patch. Chlorine application is permitted for experimental use by the Department of Pesticide Regulation.

In Huntington Harbour, solid chlorine has been used for the duration of the eradication effort (October 2000 to present).

The determination as to what is the most appropriate course of action to follow after chemical treatment remains unclear. There is concern that chlorine will only be effective at killing plant material at the surface and thus viable rhizoids may persist in the sediments. For this reason, all tarps have been left in place to prevent regrowth of this material.

To explore this issue further, a research protocol has been developed by Lars Anderson (USDA). The research calls for the removal of sediment cores from previously treated patches of *Caulerpa* throughout the duration of the eradication program. Cores will be cultured at the University of California, Davis to determine the presence of any viable *Caulerpa*. If viable *Caulerpa* is found under treatments over one year old, then additional eradication options should be considered. A small-scale field investigation was conducted in Huntington Harbour that involved removing tarps after chlorine treatment. Notes on this work can be found in the document entitled Tarp Removal From Treated *Caulerpa taxifolia* in the Huntington Harbor Infestation, Merkel & Associates, 2001.

SURVEY RESULTS

As of October 2001, Agua Hedionda Lagoon has been completely surveyed with high-intensity surveillance or better. Currently, a fall survey is being performed with eradication area surveillance level throughout the western half of the east basin and within all infestation areas. A cumulative total of 15,611 ft² of *Caulerpa* has been discovered since summer 2000 within the east basin (Figure 3). Eradication has kept pace with surveillance such that once a patch of *Caulerpa* is discovered, it is immediately treated. Thus, all *Caulerpa* discovered to date has been treated.

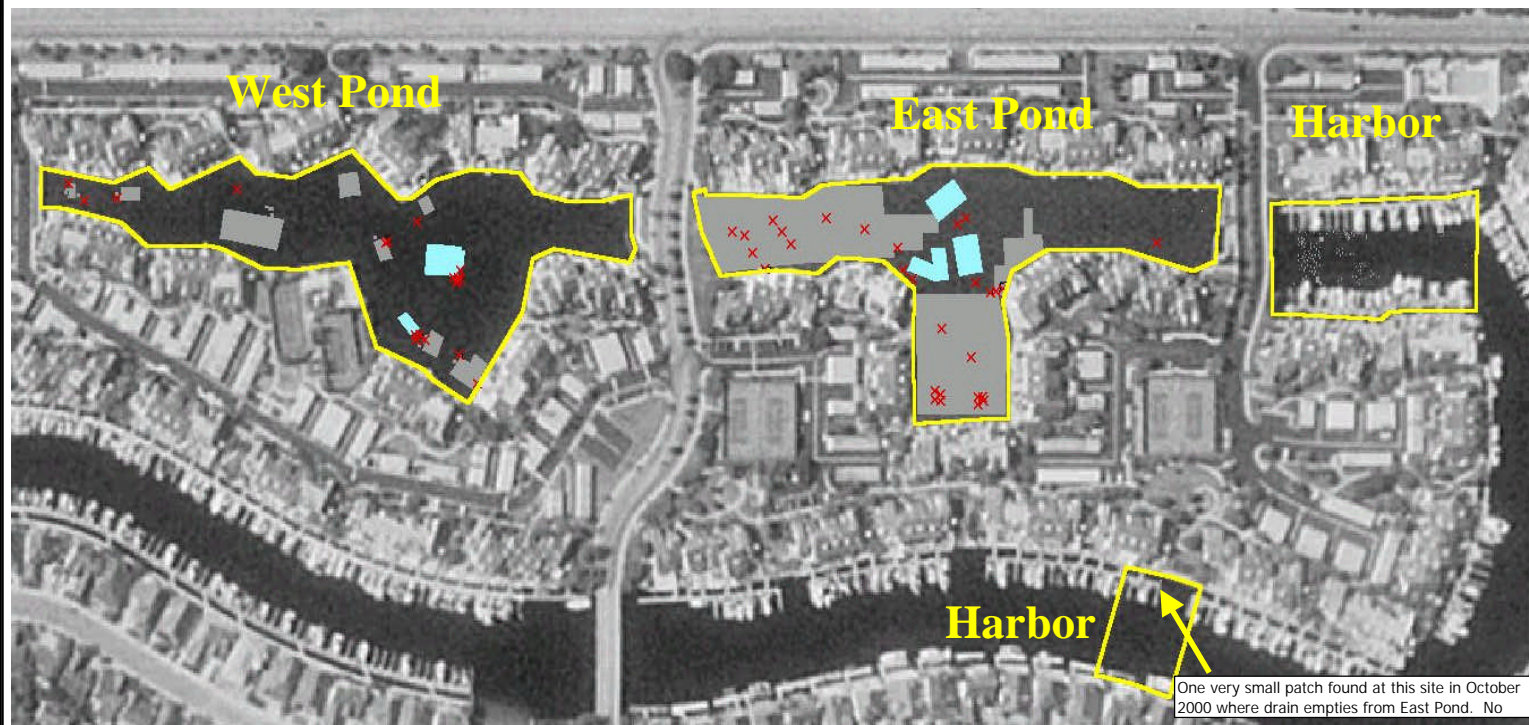
The nearshore waters adjacent to Agua Hedionda Lagoon have been surveyed by divers on three occasions. Dives focused on sandstone reefs and suspect areas identified using side-scan sonar. Suspect targets generally turned out to be surfgrass, algae, or low relief sandstone reef. No *Caulerpa* has been discovered west of Interstate 5 (central or outer basin).

It has now been over one year since eradication work began in Huntington Harbour. Post-treatment surveys have revealed additional *Caulerpa* that has been treated (Figure 4). The additional growth was generally associated with the margins of the tarps. It is believed that



**Cumulative Distribution of *Caulerpa taxifolia* in Agua Hedionda
November 2001
Carlsbad, CA**

**Figure
3**



Infested/tarped area January 2001



Infested/tarped area August 2001



***Caulerpa* detected and to be treated October 2001**



**Status of *Caulerpa taxifolia* in Huntington Harbour
October 31, 2001
Huntington Beach, CA**

**Figure
4**

Merkel & Associates, Inc.

at the time of the initial treatment, which was conducted during the winter season, the patches of *Caulerpa* were reduced in size from their summer extent. During subsequent spring and summer surveys, algal material that was not detectable in the surrounding sediment during winter appeared to have sprouted up. The Fall 2001 survey found no new occurrences in the harbor area, which was the first occasion that an infested area at either site had been resurveyed and found to have no new growth. Each of the two ponds had about twenty small occurrences, most consisting of single small thallus. The area of *Caulerpa* totaled approximately 81 ft² in the east pond and 19 ft² in the west pond.

The full survey of Huntington Harbour in spring 2001 revealed no additional infestations of *Caulerpa*.

Regionally, no *Caulerpa* has been found outside of the previously reported occurrences in Agua Hedionda Lagoon and Huntington Harbour.

FUTURE REPORTING

Currently, there is no formalized written reporting format for the findings of the SCCAT. Information has been disseminated at regularly scheduled meetings of SCCAT as well as at public meetings, agency meetings, and conferences. However, it is recognized that a written format should supplement oral briefings and can be of use for public and agency members not able to attend meetings. Moreover, a formalized reporting process allows for easy evaluation of surveillance and eradication efforts through time.

FORMAT

The report format needs to be kept simple while including up-to-date information regarding new occurrences of *Caulerpa* along with treatment status. Moreover, the reports should cover both the Agua Hedionda and Huntington Harbour sites while presenting parameters that are useful for both sites. Finally, reports should be created quarterly following each surveillance effort.

REPORT PARAMETERS

Four parameters are currently used to evaluate the eradication effort: areal extent, number of major patches, debris field area, number of infestation areas. Each of these parameters is described in detail in the report, Defining, Describing, and Assessing Benchmarks for Success in the Eradication of *Caulerpa taxifolia* at Agua Hedionda Lagoon, Carlsbad California (M&A 2001). At each infestation site, parameters will be provided for each of the current management areas. For Huntington Harbour, the management areas include the west pond, east pond, and harbor. At Agua Hedionda the management areas are east basin within grid, east basin outside grid, middle basin, and west basin.

FIRST QUARTERLY REPORT (FALL 2001)

Following completion of the Fall 2001 survey, a quarterly report will be prepared by Merkel & Associates for review by the SCCAT, which may make recommendations to improve the format of the report as needed.